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THE PHYSICAL GEOGRAPHY OF NEW YORK STATE.

PART XI.—THE CLIMATE OF NEW YORK.

BY

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BASIS FOR A STUDY OF NEW YORK CLIMATE.—The State of New York affords an exceptionally favorable and interesting field for the study of climate, owing to the diversity of its physical features, as well as to the wide variety of atmospheric influences to which it is subject. It is not surprising, therefore, to find that the first organization for local climatic observation in America was that inaugurated in 1826 by the New York Board of Regents at numerous academies under their supervision, and which was continued without a break at several stations until 1863. After that time meteorological records were maintained by a few scattered observers co-operating with the Smithsonian Institution; and in 1870–71, five fully equipped stations were established in the principal cities by the U. S. Signal Service.

The State Weather-Bureau was created by act of the Legislature in 1890, and, with the aid of over one hundred voluntary observers, its work was carried on for ten years, when the organization passed under the control of the National Weather Bureau. A great mass of data has thus been accumulated for the use of the climatologist, and may be found in the various publications mentioned in the footnote*; but in view of the improvements which have of late years

* 1—Essay on the Climate of New York, by F. B. Hough, Albany, 1857.

2—A Letter on the Climate of New York, by J. H. Coffin, contained in the "Natural History of New York State," Albany, 1843.

been made in instruments and method of observation, the investigator will find it best to depend upon the later observations, as far as practicable, and especially so when *dealing with temperature values.*

General Features of Climate.—Glancing briefly at the general features of terrestrial climate and air circulation which govern and include our local conditions, we have first to consider the effects of geographical position upon temperature, as shown in the

* ISOTHERMAL LINES OF THE NORTHERN HEMISPHERE AND WINDS OF THE UNITED STATES.

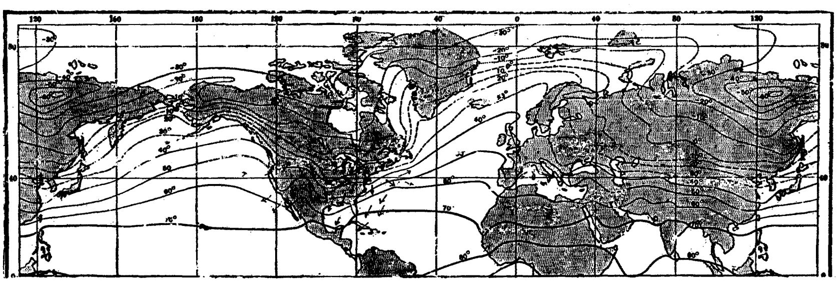


FIG. 1.—JANUARY.

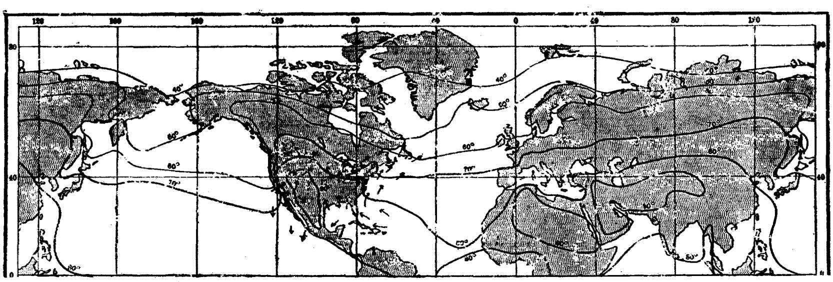


FIG. 2.—JULY.

accompanying isothermal charts of the northern hemisphere. The

3—Climatology of the United States by Laurin Blodgett, Philadelphia, 1857.

4—Observations of the N. Y. Board of Regents, Albany, 2 vols.

5—Atmospheric Temperature and Precipitation in the United States, by C. A. Schott, Smithsonian Contributions to Knowledge, Washington, 1876 and 1881.

6—Monthly Reports of the U. S. Signal Service and Weather Bureau, Washington.

7—Monthly Reports of the N. Y. State Weather Bureau, Ithaca.

8—The Climate of New York State, by E. T. Turner, contained in the 5th and 9th Annual Reports of the New York Weather Bureau, Albany.

* Note.—Fig. 1. The line of 20° passes through N. New York.

Note.—Fig. 2. The line of 70° passes through Central New York.

position and trend of the lines of equal temperature are determined by three factors:

Firstly, the decrease of temperature which occurs as we proceed northward. The average rate of this is 1° F. of annual temperature per degree of latitude.

Secondly, the rapidity of absorption and radiation of heat from land surfaces, as contrasted with the thermal stability of bodies of water. The difference between midsummer and midwinter temperatures in the interior of the American continent and over the Atlantic, at our latitude, is shown approximately as follows:

	MEAN FOR JANUARY.	MEAN FOR JULY.	RANGE OF MO. MEANS.	RANGE OF EXTREMES.
Atlantic	50	66	16	27
Interior	8	72	64	126

There is also quite as marked difference in the *daily* range of temperature between the land and the ocean.

Thirdly, the transfer of air from region to region, by means of the atmospheric circulation, tends in a marked degree to diffuse and equalize climatic conditions. The most important of these wind systems are as follows:

(*a*) The southwesterly winds which prevail over the temperate zone, in consequence of the heat circulation between high and low latitudes, conjoined with the earth's rotation. These may be called *Planetary Winds.*

(*b*) Winds of the monsoon type, blowing landward in summer and seaward in winter, as the result of unequal thermal conditions of continents and oceans.

(*c*) Winds accompanying those rapidly shifting areas of high and low barometer, known, in their most pronounced form, as cyclonic storms and anticyclones, respectively (see fig. 4, page 106); air flowing *toward* centres of low pressure, and *out from* centres of high pressure. It is important to note, in this connection, that in the northern hemisphere the rotation of the earth tends constantly to deflect air currents toward the right of their direction of motion; hence the circulation about high and low areas is not direct, but spirally inward and outward.

The general westerly circulation (*a*) evidently must tend to

bring the moisture and equable temperature of the ocean well inland over the western sides of the continents, as we find to be the case on our Pacific slope and along the northwest coast of Europe; while in a similar manner the conditions of the continental interior will more generally prevail along the eastern coasts. The two cases are fairly presented by the following:

TABLE OF MEAN TEMPERATURES.

		MIDSUMMER.	MIDWINTER.	DIFFERENCE.
West Coast........	San Francisco......	60°	50°	10°
Interior..........	St. Paul..........	72	8	64
East Coast.........	New York City.....	74	31	43
West Coast.......	London, Eng......	64	38	26

The monsoons (class *b*) in winter strengthen the dry, cold winds from the interior eastward toward the ocean, but in summer tend to reverse the east-moving current; hence we must expect the continental type of climate to be much more strongly felt over the eastern States in winter than in summer. It must be noted, however, that the summer monsoon does not reach us directly as a cool sea-wind, since it is not strong enough to overcome the eastward drift until we approach the southern States and Mexican Gulf; but passing inland, over that semi-tropical region, it unites with the general current, and reaches us as the warm and moist southwesterly wind of summer, giving the abundant rainfall characteristic of that season.

Finally, the temporary winds of class *c* are responsible for the *variability* of weather which is so marked a feature of our climate. The low barometer areas of America move eastward at an average rate of 800 miles per day, and in the large majority of cases pass centrally over the vicinity of the Great Lakes and St. Lawrence valley, drawing in masses of air from the ocean and the south, at the same time giving rain or snow over the northeastern States. These disturbances recur at intervals of three or four days, on an average, in winter, but with less frequency and strength in summer. They are generally followed by high-pressure systems from the interior, whose outflowing winds are characteristically dry and cold; so that, in fact, our winter climate is made up of constant alternations of maritime and continental conditions.

Figure 3 shows graphically the fluctuations of temperature and weather to which New York is subject, and their close relation to

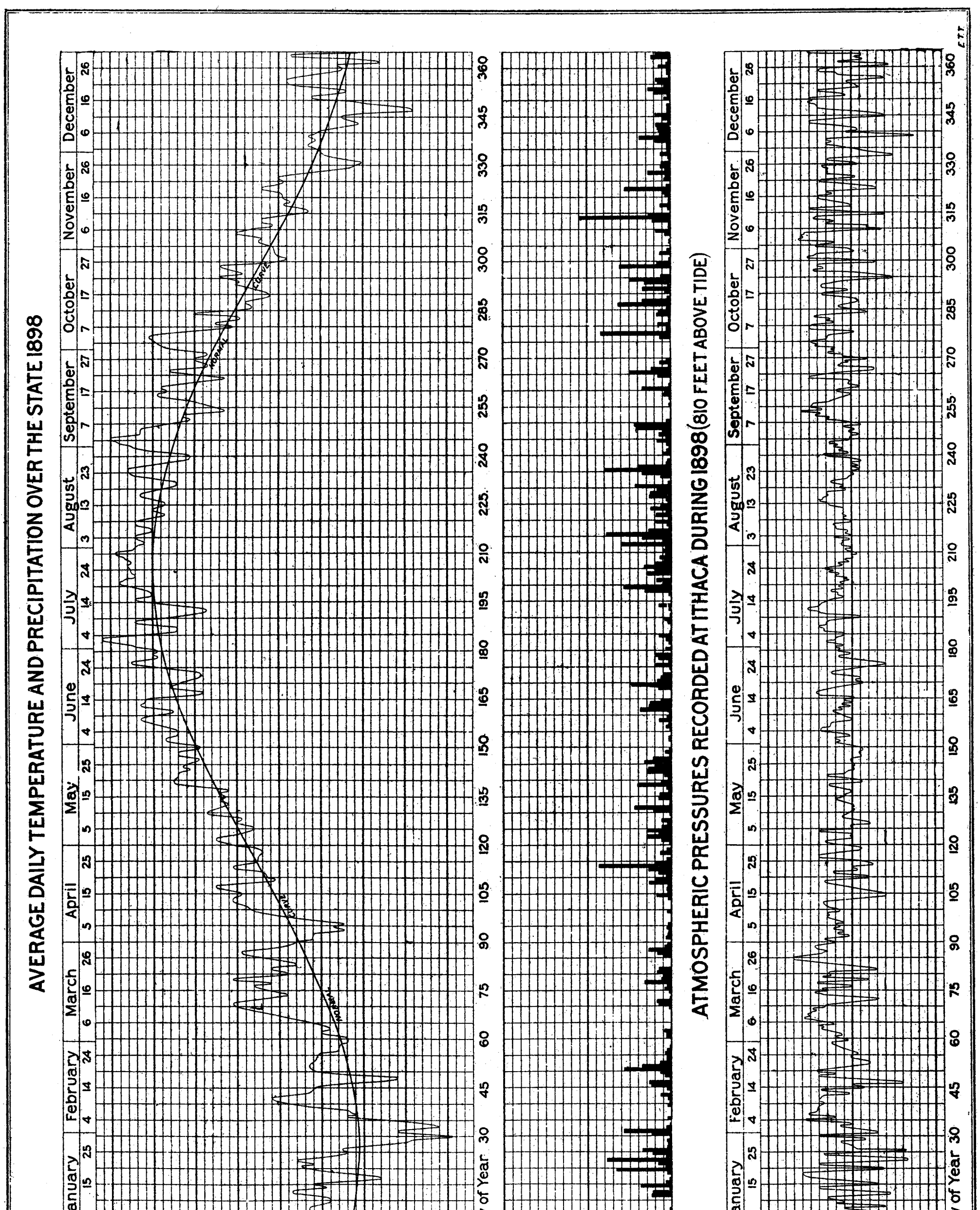

AVERAGE DAILY TEMPERATURE AND PRECIPITATION OVER THE STATE 1898
TEMPERATURE - DEGREES FAH.
RAINFALL - INCHES.
Day of Year
NORMAL
CURVE
ATMOSPHERIC PRESSURES RECORDED AT ITHACA DURING 1898 (810 FEET ABOVE TIDE)
PRESSURE - INCHES.
January
February
March
April
May
June
July
August
September
October
November
December

FIG. 3.

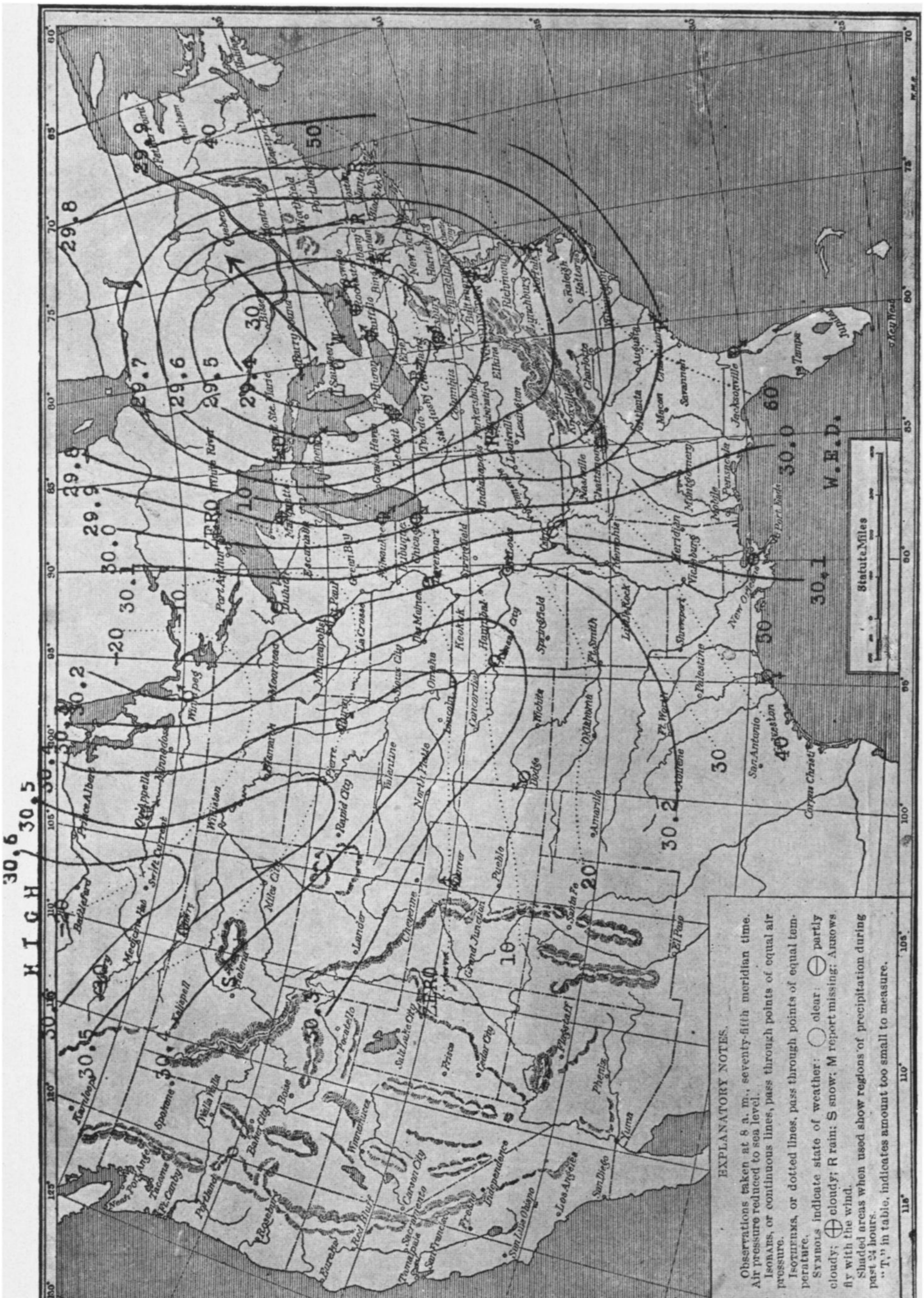


FIG. 4.—WEATHER MAP, FEBRUARY 13, 1900.

the passage of high and low barometer areas near the State. (It should be noted that the temperatures indicated by the wave-line are the daily averages for the entire State, and not the local extremes of heat and cold.)

The conditions attending a cyclonic storm and the succeeding anti-cyclone are shown by the accompanying weather-map (Fig. 4) for 8 A.M., February 13th, 1900. The tracings of the self-recording barometer and thermometer at Ithaca on the same date are reproduced in Fig. 5, together with the wind direction. It will be seen

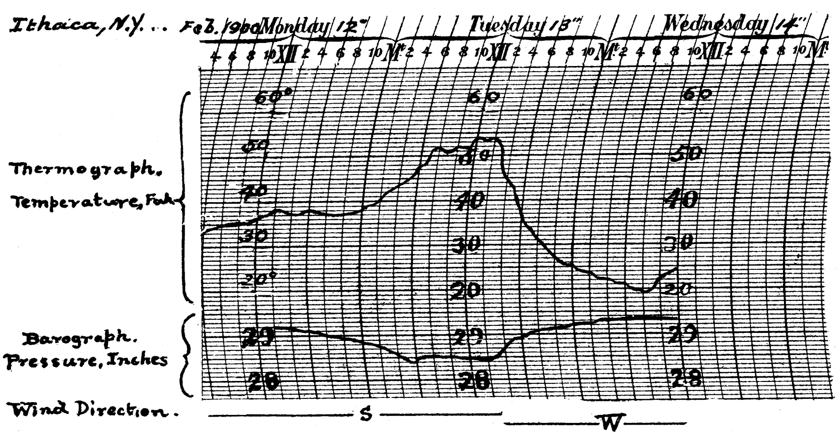


Fig. 5. Temperature Pressure and Wind Direction at Ithaca. Feb 12th to 14th

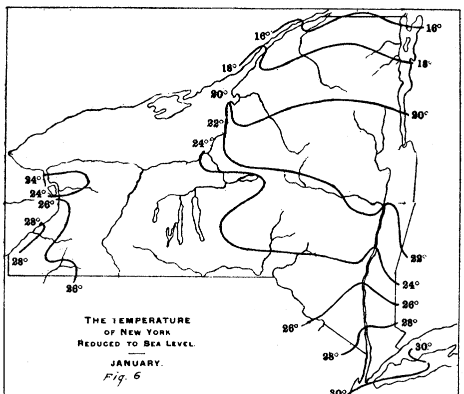
that the approach of the storm, indicated by a falling barometer, gave southerly winds and rising temperature until 2 P.M., when the storm centre passed nearest the station. The wind then immediately shifted to the westward, increasing in force, and at the same time the temperature fell, at first very suddenly, and then gradually, until the crest of the "high" passed on the following day.

The element technically known as *variability* of temperature, *i. e.*, the average difference from day to day, amounts to over 10° in Maine and Quebec, for the month of January, when the maximum value is reached. The mean value for New York State is 8°; over the south Atlantic and Gulf coasts, 6°; on the coast of California, 2°.

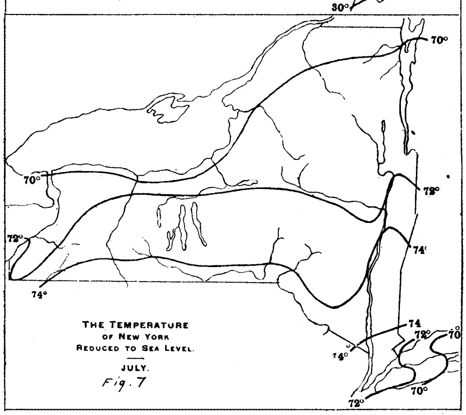
In the immediate vicinity of our coast, the greater part of the annual precipitation occurs in winter, when the low areas are most frequent and intense; but in the interior of the State, heavy local

rains during the period of the summer monsoon bring the maximum fall of the year at that season.

INFLUENCE OF GREAT LAKES.—We have thus far omitted to mention the important modifications of our climate due to the Great Lakes. These bodies of water follow the seasonal temperature changes much more closely than does the ocean, owing to their smaller mass; but nevertheless such scanty data as have been gathered indicate that the surface of Lake Ontario averages from 10° to 15° warmer in winter, and cooler in summer, than the adjacent land areas; hence the northwesterly winds of winter, in passing over the lake, are raised to a temperature considerably higher than obtains on the north shore. This influence is felt throughout the portions of the State lying to the south and east of the lakes, although decreasing rapidly as we proceed inland. In northern New York, on the other hand, the coldest winds of winter are not affected by the lakes, and in consequence the winters are much more severe than could be expected as a result of the higher latitude of the region alone.



THE TEMPERATURE OF NEW YORK REDUCED TO SEA LEVEL. JANUARY. Fig. 6



THE TEMPERATURE OF NEW YORK REDUCED TO SEA LEVEL. JULY. Fig. 7

The southerly winds which predominate during the warmer portion of the year, of course, reach this State uninfluenced by the lakes, hence the temperature conditions are much more uniform over our entire area than in winter. The tempering effect of the lakes and ocean is clearly brought out by the accompanying isothermal charts, from which other sources of variation have been largely eliminated by reduction of temperatures to sea-level.

LOCAL CLIMATE.

Topographical Features.—The main portion of New York State is a broken and irregular plateau, whose average elevation is 1,200 to 1,500 feet above tide. This plateau is bordered on the west and northwest by considerable tracts of level lowland along the shores of the Great Lakes and the St. Lawrence River; while near the eastern border the valleys of the Hudson River and Lake Champlain form a deep channel extending from the seaboard directly northward into Canada.

Along the western side of this depression the highlands reach their greatest elevation in the mountain systems of the Adirondacks, Catskill, and several minor ridges; while on the east also the valley is closed in by the high hills of New England. The Hudson Valley is united to the lowlands of the Great Lakes by the narrow valley of the Mohawk, which divides the central plateau from that of the northern or Adirondack region. Among the more important minor depressions are the valleys of the Central Lakes and those of the Delaware and Susquehanna Rivers and their tributaries.

Elevations and depressions of land surface affect temperature conditions in three important ways:

Firstly, the temperature average for the day (24 hours) decreases with elevation at the rate of about 0.3° and 0.4° per hundred feet in winter and summer, respectively. This rule should give to the plateaux a temperature 4° to 6° lower than that at sea-level.

Secondly, the highlands act as a shelter or windbrake for the neighboring valleys; and this effect becomes very important in a territory so irregular as that of New York. The temperate climates of the various "fruit belts" of the State are due both to a sheltered situation and to the proximity of bodies of water.

Thirdly, a flow of cold dense air from the hill slopes to the valley bottoms occurs on clear, still nights, and frequently so much reduces the temperature of the lowlands as to cause severe frosts, which are escaped at higher levels; and, since the highest midday temperature also occurs in the valleys, their daily range is often excessive. The following example of the conditions in Central New York during a cold wave will sufficiently illustrate this point:

TEMPERATURE (FAHRENHEIT).

LOCATION.	Altitude.	JANUARY 9.			JANUARY 10.			JANUARY 20.			JANUARY 21.			FEBRUARY 6.		
		Max.	Min.	Range.	Max.	Min.	Range.	Max.	Min.	Range.	Max.	Min.	Range.	Max.	Min.	Range.
	Feet															
Oxford (Hill).........	1250	21	4	17	17	—8	25	11	—24	35	21	—10	31	22	—3	25
Brookfield (Val.)......	1350	24	—3	27	17	—16	33	6	—28	34	21	—17	38	30	—16	46

NOTE.—The rapid rise of the general surface of the eastern plateau brings the valley bottom at Brookfield above the level of Oxford. The distance between the stations is about thirty miles.

The different thermal conditions at hill and valley stations are also shown by tracings of thermographs in Fig. 8.

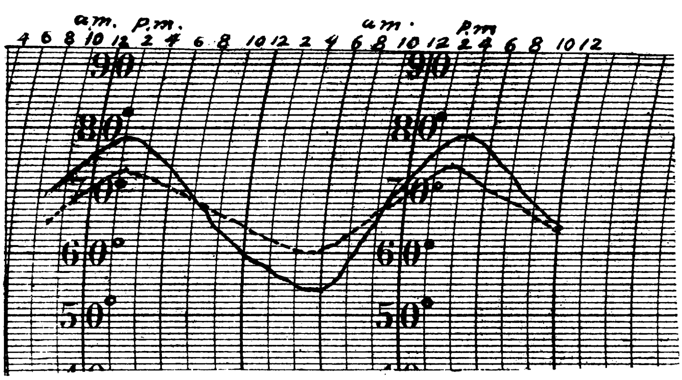


Fig 8 Temperature curves at Mountain and Valley stations of New York Aug 21st and 22st 1891
---Temp. at Minnewaska Elevation 1800 ft
— " " Port Jervis 470 "

The nocturnal valley-winds are an important climatic factor, since they bring a cool and refreshing air at night which is not felt on the plains or upper hill slopes. A special study of the subject has been made at Ithaca, in the Cayuga Lake valley, where it is found that the breeze usually arises from one to two hours after sunset, blowing from the south down the channels of the two principal streams flowing into Cayuga Lake, and gradually gaining a velocity of 10 or 12 miles per hour as the night advances. Small balloons set adrift at night were often observed to drift northward with this surface current until an altitude of 200 or 300 feet had been reached, when they were caught by the prevailing wind, and abruptly changed their course to the eastward.

We are now prepared to consider in more detail the temperature conditions of the State, as exhibited by the accompanying tables and charts (Figs. 9, 10 and 11).

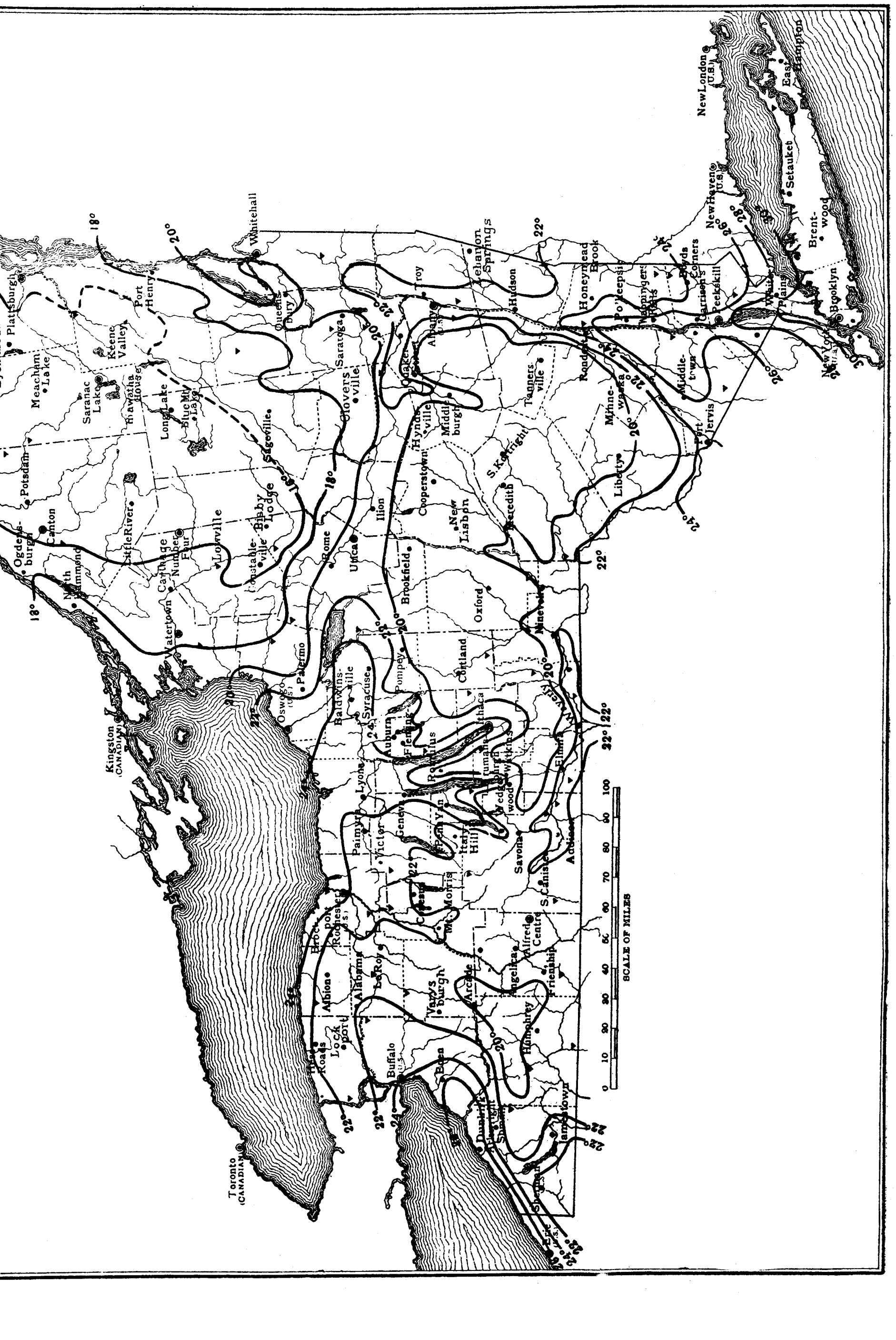


FIG. 9.—MAP OF THE STATE OF NEW YORK SHOWING THE NORMAL TEMPERATURES FOR JANUARY.

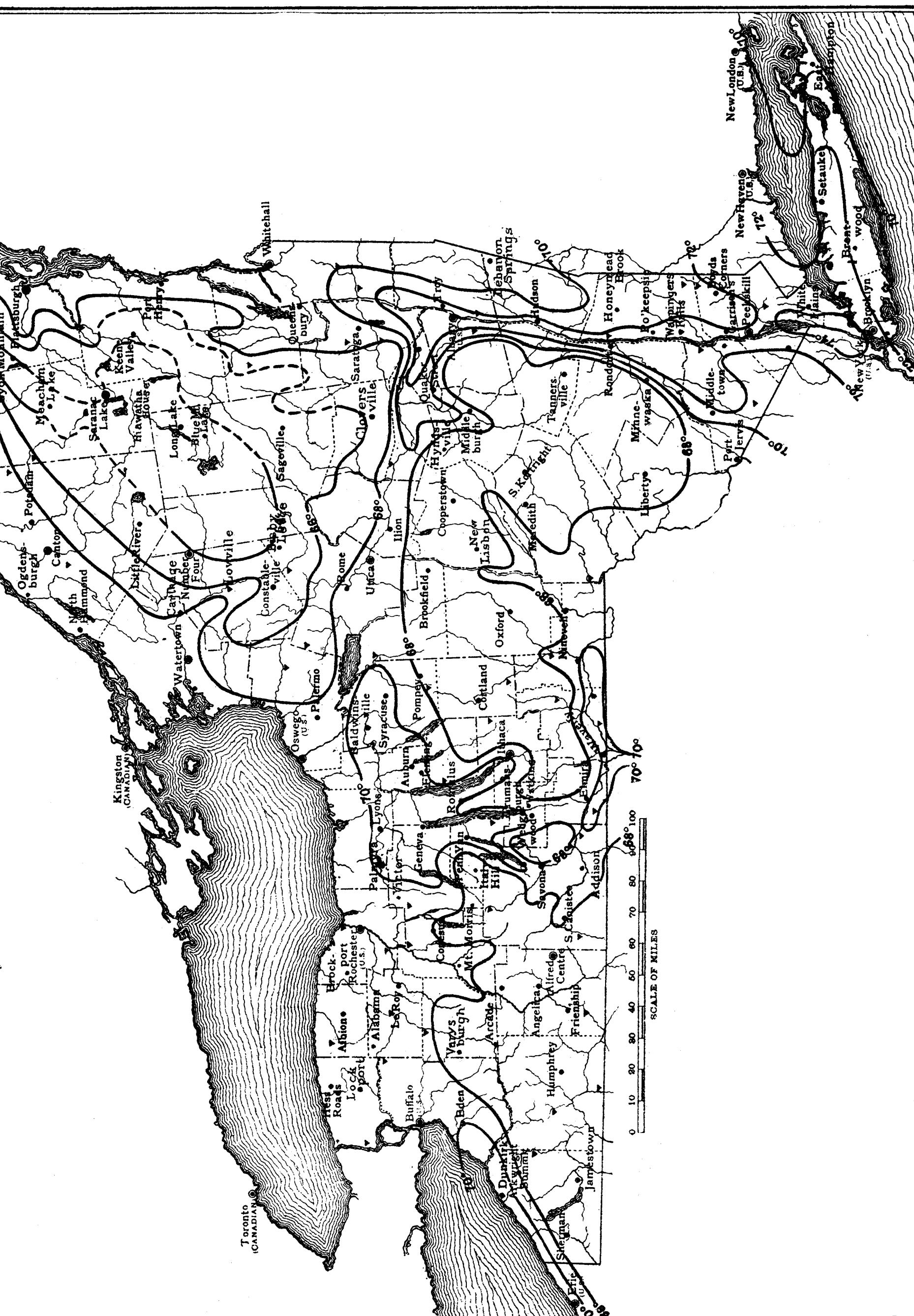


FIG. 10.—MAP OF THE STATE OF NEW YORK SHOWING THE NORMAL TEMPERATURES FOR JULY.

FIG. 11.—MAP OF THE STATE OF NEW YORK SHOWING THE NORMAL TEMPERATURES FOR THE YEAR.

TABLE I.—MONTHLY AND ANNUAL TEMPERATURE AVERAGES, DERIVED FROM RECORDS OF TEN YEARS OR MORE.

REGION AND STATION.	MEAN TEMPERATURE (FAHR.).												
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Year.
ATLANTIC COAST:													
Setauket, L. I.	31	30	36	47	58	67	72	71	65	54	44	36	51.0
New York City	30	31	37	48	60	69	74	72	66	55	44	34	51.7
CENTRAL PLATEAU:													
Cooperstown.	20	21	28	41	54	64	68	65	57	46	35	25	43.9
Angelica	22	22	30	43	55	65	68	64	58	46	36	26	44.6
NORTH'N NEW YORK:													
Number Four	17	17	25	39	52	61	64	62	56	44	32	22	41.0
Plattsburg	16	17	26	41	55	65	70	68	58	47	34	22	43.2
GREAT LAKES:													
Buffalo	25	25	31	42	54	65	70	69	62	51	39	30	46.8
Rochester	24	25	31	44	57	66	71	69	62	50	39	30	47.4
HUDSON VALLEY:													
Albany	23	24	32	46	59	69	72	71	63	51	39	29	48.3
ENTIRE STATE:													
(50 stations)	22	23	29	42	56	65	69	67	60	48	36	26	45.4

TABLE II.—EXTREMES OF TEMPERATURE FOR THE YEAR. FROM RECORDS OF THE PAST TEN YEARS.

REGION AND STATION.	ELEVATION.	MINIMUM.			MAXIMUM.		
		Average for entire period.	Lowest during entire period.	Highest Min. during period.	Average for entire period.	Highest during entire period.	Lowest Max. during period.
COAST:							
Setauket	40	+ 4	− 5	+12	95	98	88
New York City	300	+ 2	− 6	+10	95	99	91
HUDSON VALLEY:							
Albany	97	− 9	−16	− 4	96	100	94
CENTRAL PLATEAU:							
New Lisbon	1234	−19	−26	−13	92	94	87
Angelica	1340	−20	−27	−10	92	95	88
NORTHERN NEW YORK:							
Number Four	1571	−25	−31	−17	88	91	85
Canton } Potsdam	300 } 300	−27	−43	−15	94	98	90
Plattsburg	180	−18	−25	−12	94	96	90
GREAT LAKES:							
Buffalo	770	− 3	−13	+ 7	90	95	84
Rochester	520	− 4	−10	+ 6	95	99	92

The Atlantic Coast Region.—The nearest approach to a maritime climate to be found within the territory of New York is that of Long Island. The values given for Setauket, in table 1, indicate a midwinter temperature nearly as high as that for Philadelphia, and 9° above the average for the State; while the midsummer temperature is but 3° above that average. The effect of the ocean and Sound in moderating the *daily* ranges, and especially the winter minima, is even more marked, so that the region is extremely well adapted to the raising and early marketing of tender fruits and vegetables. The first killing frost occurs, near the coast, about the beginning of November, and the last about the middle of April, on an average. Usually, during the winter, the ground is covered with snow for brief periods only.

The *sea breeze* is the most characteristic and important feature of maritime climate in summer. In fair weather the land-wind, which is usually felt at night, ceases soon after sunrise, and the temperature rises rapidly until 9 or 10 o'clock, when the cool breeze from the ocean sets in, gaining strength until early afternoon, when a velocity of 10 or 15 miles per hour may be attained. In general the breeze penetrates inland about ten miles, but on southern Long Island its force and penetration are greatly augmented by the prevailing southerly wind of summer. The accompanying diagram, exhibiting typical hot-weather temperature curves for an inland and coast station, brings out very clearly the moderation of midday heat due to the sea breeze. (Fig. 12.)

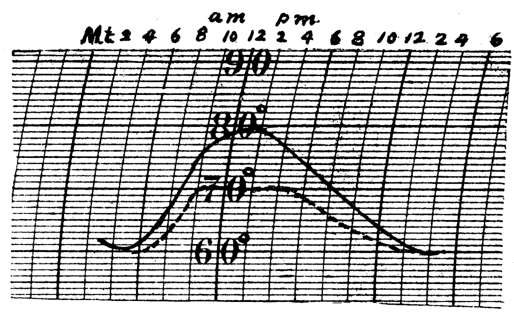


Fig. 12 Temperature as affected By Sea-Breeze.
— Inland Station
---- Sea Coast Station

The *Central Plateau*, extending from the Great Lake region on the west to the Hudson Valley on the east, has a more uniform temperature than might be expected to obtain over so large an area, since the general rise of the surface toward the south and east largely counterbalances the thermal effects resulting from proximity to the ocean and a more southerly latitude. Hence, we may consider the higher levels of this region to be fairly represented by the

averages given in the table for Angelica and Cooperstown. The temperature of this section is usually sufficiently low to maintain a continuous covering of ice and snow throughout the winter; but the larger valleys are subject to frequent thaws, which may leave the ground bare for considerable periods. Only hardy fruits can thrive on the highlands, and even in the valleys the temperature commonly falls low enough to damage, or even kill, peaches.

The midsummer maxima over the plateau average about 4° lower than on the lowlands, and at the summits of the higher hills and mountains the midday heat is, of course, still more moderate. (See fig. 8, p. 110.)

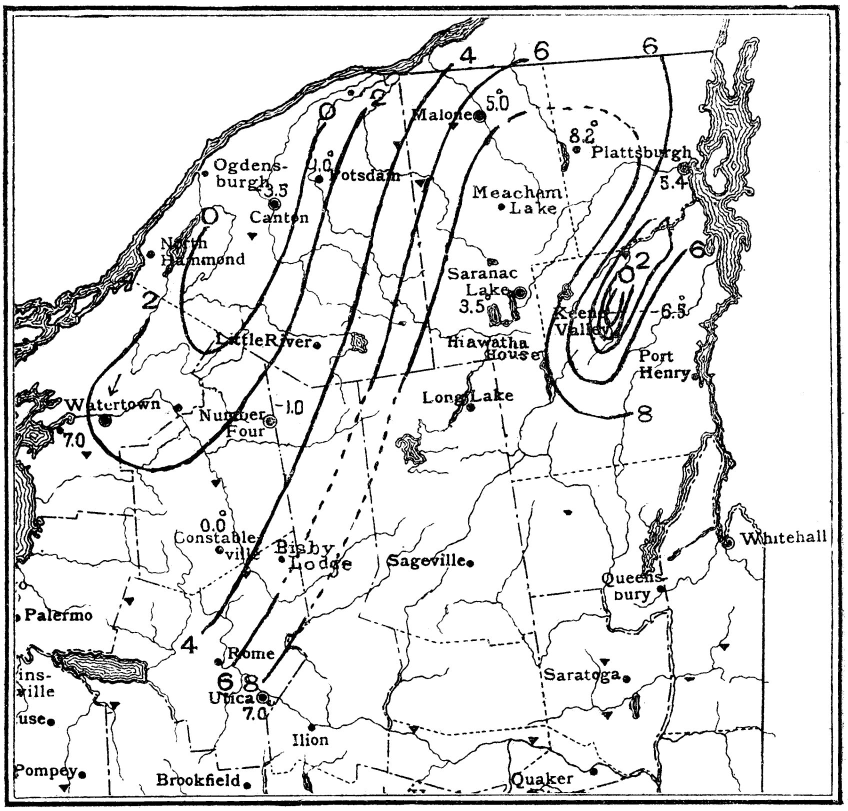
The average duration of ice in Otsego and Cazenovia lakes (altitude about 1,200 feet) is from December 15th to April 15th. The first killing frost is likely to occur as early as October 1st, and the last in May.

Northern New York has a *winter* climate almost as severe as that of the northern interior States, while the summer heat is nearly as great as at equal altitudes in southern New York; and since the region is largely exempt from maritime influences, it is especially liable to sudden and very abrupt changes of temperature. The lakes and forest tracts of the Adirondack mountains have usually a heavy covering of firm snow and ice from the latter part of November until the close of April, so that the air is much dryer during that period than in warmer portions of the State. To this fact, together with the presence of large areas of pine woodland, is probably due the favorable effect of the Adirondack climate upon lung diseases; an effect, however, which is shared by the higher regions of southeastern New York.

The minimum temperatures recorded in the St. Lawrence Valley are as low as those of the Adirondack region; in fact, the lowest temperature on record for this State (−46°) was observed at the border of the St. Lawrence Valley. There, as in all regions of contiguous mountain and lowland tracts, we may often observe that the temperature actually *increases* with altitude during the progress of a cold wave. This phenomenon, known as *inversion of temperature*, indicates that the cold which accompanies cloudless areas of high barometer is largely a surface phenomenon, due to loss of heat from the earth by radiation. The diagram given herewith shows a typical case of inversion, derived from the records of the State Weather Bureau. Had the temperature decreased with altitude, at the usual rate, a reduction of the values to sea-level would have given a uniform temperature for the entire region; whereas in this case the isotherm

of o° is found at the lowest levels, and that of 8° in the highest portion of the Adirondacks.

FIG. 13.—INVERSION OF TEMPERATURE IN NORTHERN NEW YORK, DECEMBER 8TH, 1890.



ISOTHERMAL LINES SHOW THE MEAN DAILY TEMPERATURE AS REDUCED TO SEA LEVEL BY DEDUCTING 0.3° FROM THE ACTUAL TEMPERATURE FOR EACH 100 FEET OF ELEVATION. SMALL FIGURES SHOW ACTUAL TEMPERATURES. [THE MEAN TEMPERATURE AT KEENE VALLEY WAS—6.5°.]

Navigation on the St. Lawrence River is closed by ice, on the average, from about the middle of December until early in April.

The Champlain and Hudson valleys owe their high summer temperature to a sheltered position, as well as to the predominance of southerly winds throughout their extent at that season. The northerly winds of winter, on the other hand, have a clear sweep as far south as the high ridges of the lower Hudson Valley, so that the temperature is often nearly as low as upon the adjacent highlands. The advance of spring, however, is comparatively rapid, especially

to the southward of the Mohawk Valley; hence this region is well adapted to the growing of early vegetables and small fruits.

The broadest portion of Lake Champlain is commonly frozen over from January to early April. Navigation closes on the Hudson, at Albany, on December 16th, and opens on March 20th, for the average year.

The Lake Region.—Inspection of table I and Figs. 6 and 7 shows that the tempering effect of the Great Lakes is most marked in winter, when the prevailing winds must pass over their surface before reaching New York. This effect is clearly brought out by comparing the temperature recorded on the north and south sides of the lakes during the prevalence of a cold wave.

DATE.*	NORTH SHORE.		SOUTH SHORE.	
	KINGSTON.	TORONTO.	OSWEGO.	ROCHESTER.
January 19, 8 A.M.	+ 2	+4	+12	+16
January 19, 8 P.M.	− 6	0	+ 8	+12
January 20, 8 A.M.	−22	−8	− 2	+ 6

* The winds were northerly throughout the observations.

Here Lake Ontario appears to have maintained the temperature at Rochester, from 14° to 28° above the point to which it would otherwise have fallen. The frequent occurrence of conditions similar to the above gives to the southern shore of Lake Ontario an average mid-winter temperature 5° higher than that of the northern shore. It thus becomes possible, in our lake district, to raise peaches, grapes and the tender vegetation which can scarcely exist in the adjacent portions of Canada, nor even in the southern interior of the State. The noted grape belt of Chautauqua County, in which over 30,000 acres of that fruit are under cultivation, owes its mild climate both to the proximity of Lake Erie and to the high hills which rise on the eastern side in a semi-oval form. Killing frosts rarely occur in this locality before the close of October; and their latest date in spring is usually previous to May 10th.

The eastern portion of Lake Erie is commonly frozen over during a portion of the winter, navigation being closed at Buffalo from early in December to April. Lake Ontario, owing to its greater depth, is less obstructed by ice, and at Oswego the period of navigation is two or three weeks longer than at Buffalo.

A small daily range of temperature obtains at Lake Stations in winter, owing to the almost constant cloudiness of the region as well as to the tempering effect of the water.

The thermal conditions of the Cayuga and Seneca Lake valleys are so similar to those of the Great Lakes that no special treatment of them is necessary. Cayuga Lake is seldom, and Seneca Lake never, frozen over completely. Their immediate shores have an equable temperature, which, with the shelter afforded by the surrounding hills, renders this region a favorable one for fruit culture.

PRECIPITATION.

The amounts of annual precipitation in different sections of the State are mainly determined: first, by proximity to various sources of vapor or vapor-laden air-currents; and, secondly, by the character of local topography. In the case of New York State, we may say that, under similar conditions, the precipitation is roughly proportional to the altitude of land-surfaces. This rule does not apply to the central and southern Atlantic States, whose mountain ridges are parallel to the prevailing direction of vapor-bearing winds.

As has been stated, the Atlantic Ocean furnishes the principal vapor supply of the northeastern States. While passing inland with easterly winds the moisture is, in the first place, largely precipitated over the mountains of New England, as is rendered apparent by the extraordinary rainfall on Mount Washington, averaging over 90 inches per annum. A similar condition no doubt exists through the Green Mountain system near the New York border; and hence the lowlands to the westward, including the Champlain and upper Hudson valleys, receive a somewhat deficient supply as compared with that of the State as a whole. A marked increase of rainfall is again found in the Adirondack highlands, and beyond these a decrease in the St. Lawrence valley.

Sea-winds from the southeast find no obstruction on the immediate coast of New York; but passing inland they meet the abrupt hill ranges of the southeastern counties, and give to each a copious rainfall as compared with that of the intervening valleys. Liberty, in the mountainous region of Sullivan County, also shows the direct influence of the sea-wind both by its large annual precipitation and by a pronounced secondary maximum in winter—a feature not noticed at stations further northward.

Western New York receives an appreciable portion of its vapor supply from the Gulf of Mexico, judging from the frequent southwesterly direction of the rain-winds, and also from similarities existing between the rain types of the Lower Lakes and those of the Gulf and the Mississippi and Ohio valleys. The total precipitation over the depressed area occupied by the Lakes is rather below

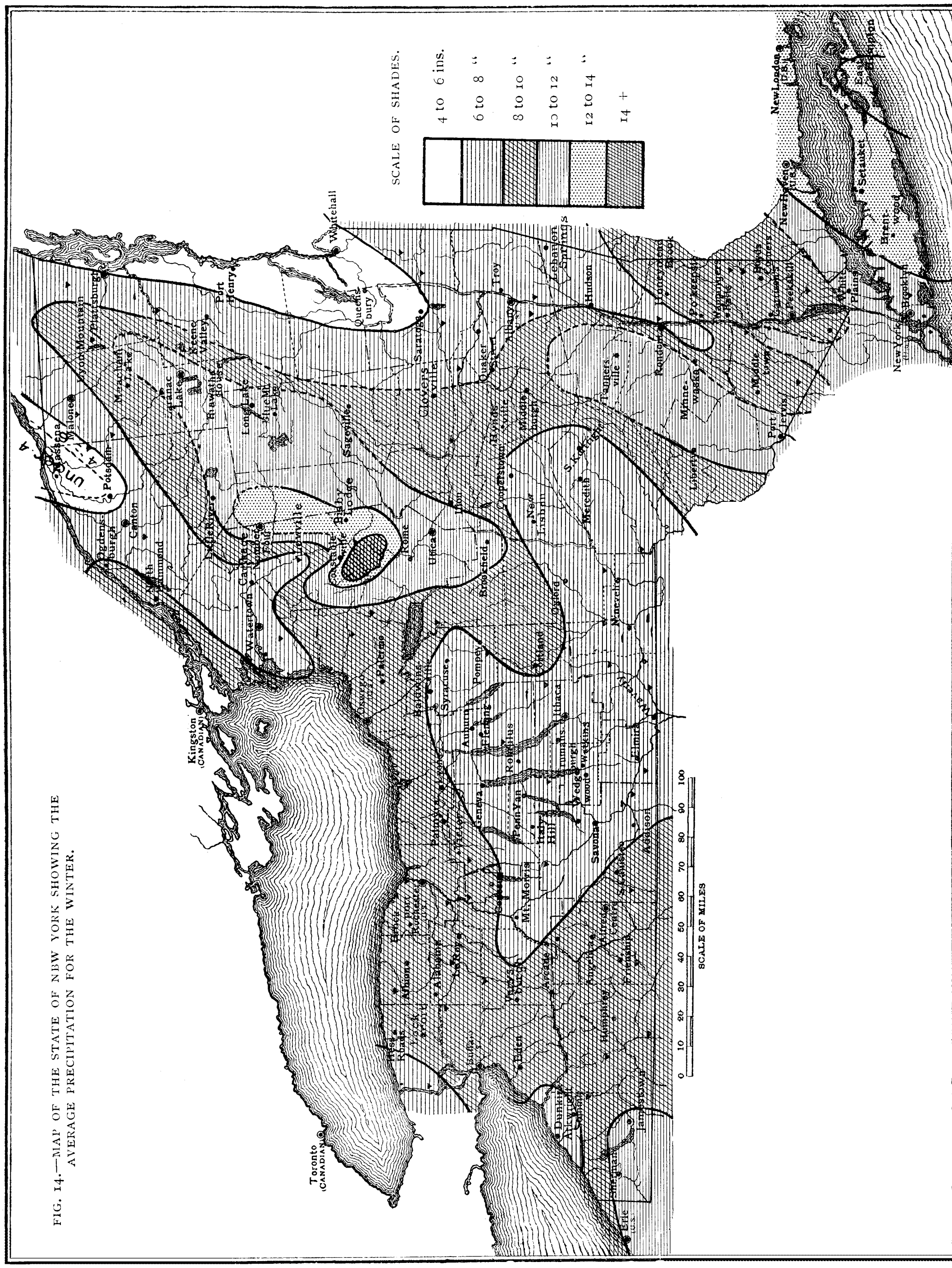


FIG. 14.—MAP OF THE STATE OF NEW YORK SHOWING THE AVERAGE PRECIPITATION FOR THE WINTER.

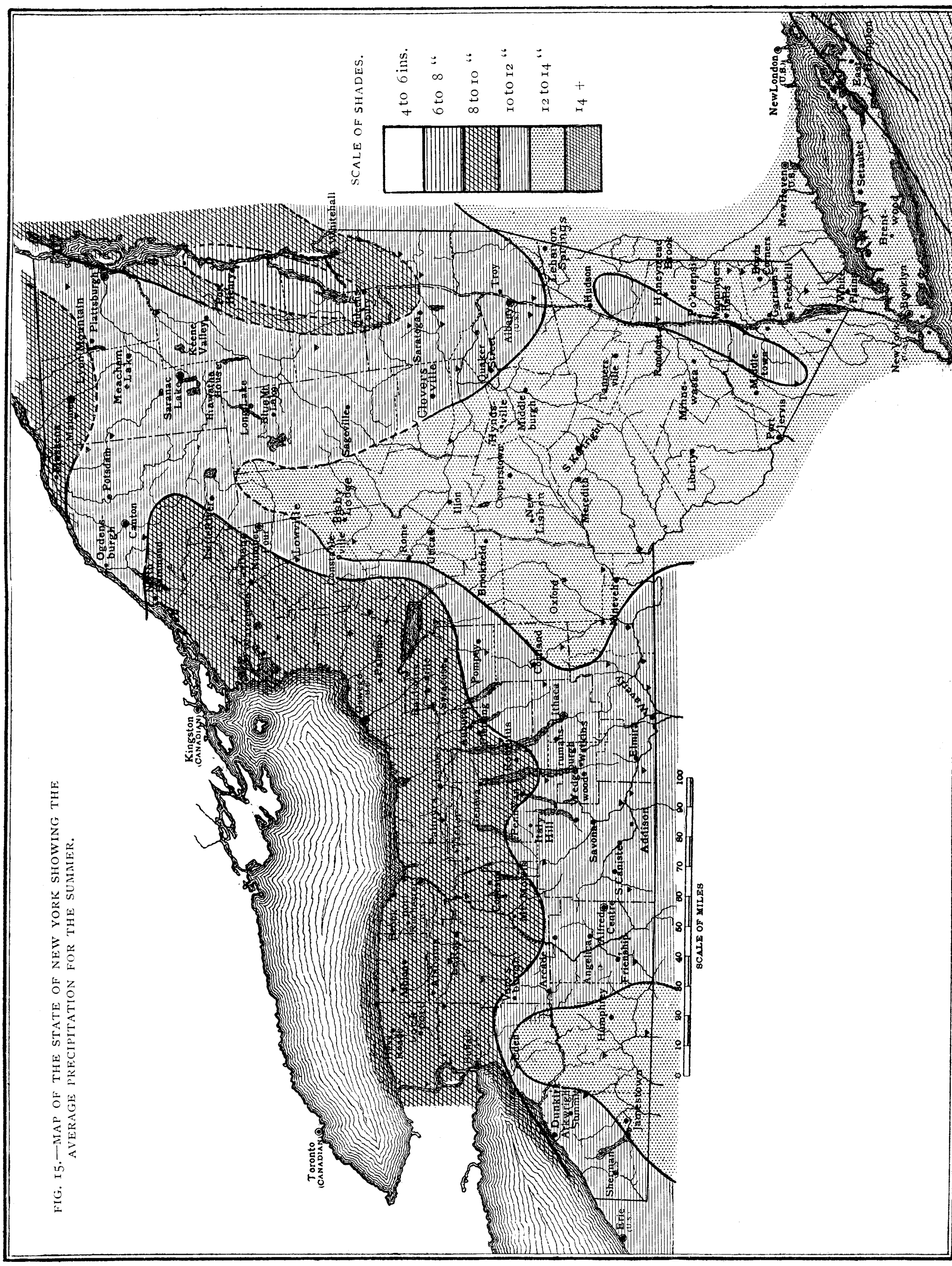


FIG. 15.—MAP OF THE STATE OF NEW YORK SHOWING THE AVERAGE PRECIPITATION FOR THE SUMMER.

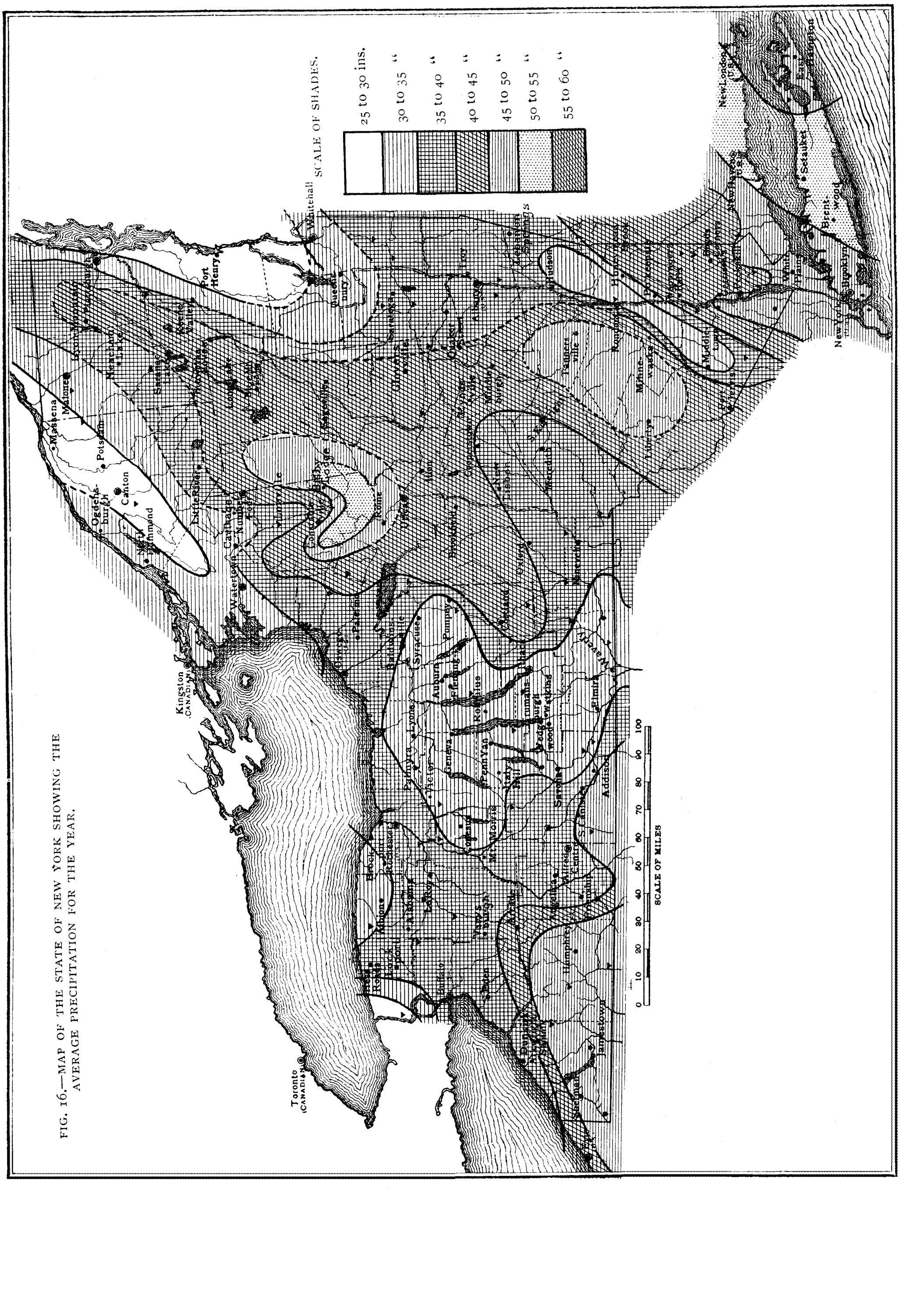


FIG. 16.—MAP OF THE STATE OF NEW YORK SHOWING THE AVERAGE PRECIPITATION FOR THE YEAR.

the average for the State; but, wherever the surface rises abruptly from their shores, the amount rapidly increases and considerably exceeds that common to equal altitudes in the interior. The winter maximum appears prominently in a large snowfall over the southwestern highlands, and still more so through a section including the hills of Lewis County, the upper Mohawk valley and an adjacent spur of the eastern highlands in Madison County.

The rainfall in central New York is generally abundant, although somewhat less than that of the southeastern and southwestern highlands. A deficiency, as compared with the average for the State, exists in the principal valleys of the Susquehanna system and also in the depression of the Central Lakes.

Records have not been kept long enough to establish, with accuracy, the amount of rainfall in the central Adirondack region. The brief series of observations obtainable from points near the eastern and western limits of the plateau have been carefully analyzed by comparison of individual monthly values with those of the adjacent stations in the Champlain and St. Lawrence valleys, the highlands showing a marked excess in all cases. The amounts of rain in the interior, shown by the accompanying charts, were estimated from the data of border stations, somewhat modified by the character of local topography.

Monthly and Seasonal Fluctuations of Rainfall.—The fluctuations in the average or normal amount of rainfall from month to month do not occur in a uniform manner over the entire area of New York, but must rather be classed under several quite distinct types, depending upon atmospheric conditions, which have already been summarily described. The character of various types and their important modifications are shown in considerable detail by Figures 17, 18 and 19.

A close approach to the continental type of rainfall, with its early summer maximum, is found over the central plateau regions (including the eastern and western plateaux and the southern Adirondack region), as represented by Cooperstown. Proceeding eastward to the central Hudson valley, a July maximum is found which extends through the Champlain valley and over the Province of Quebec. In the southern Hudson valley the maximum varies from July to August, while south of the highlands the maximum occurs in August. This condition also extends over Long Island to Setauket, but disappears at East Hampton and Block Island. The Great Lakes and St. Lawrence Valley show a June or July maximum, which, however, is secondary to that of autumn.

FIG. 17.

FLUCTUATIONS OF NORMAL RAINFALL.

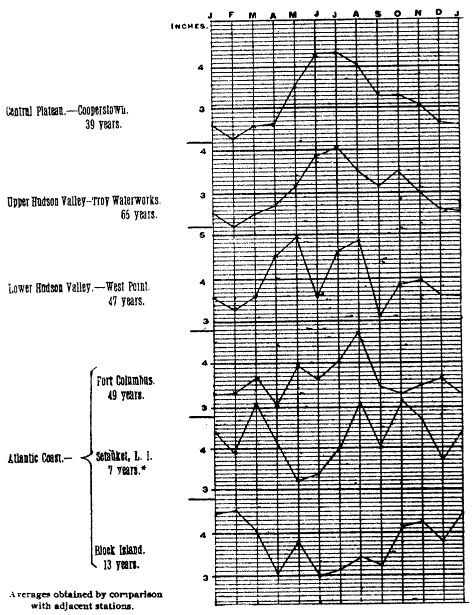


FIG. 18.

FLUCTUATIONS OF NORMAL RAINFALL.

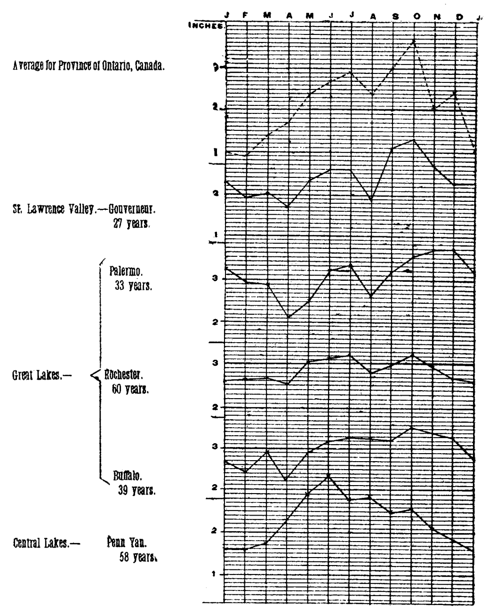
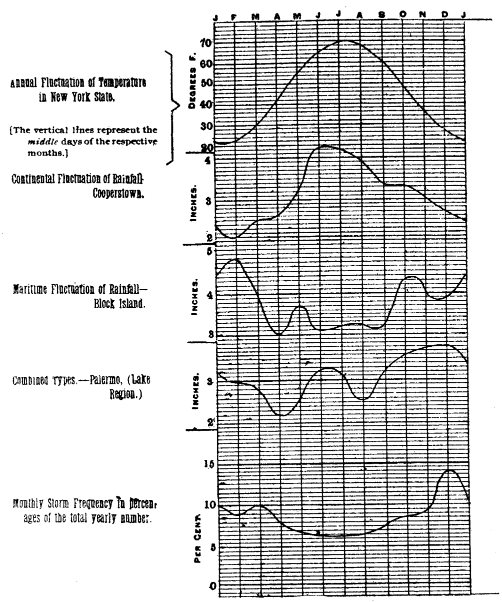


FIG. 19.

RELATION OF RAINFALL TO STORM FREQUENCY AND TEMPERATURE.



Autumn Rains.—Over the State, generally, a large precipitation obtains in October, as compared with the months immediately preceding and following. This constitutes the principal maximum of the year at several stations of the St. Lawrence Valley, the central part of the Great Lake Region, Central Long Island, and beyond the limits of New York, in New Brunswick, Nova Scotia, and Ontario. Within this State an October *minimum* is found only in the vicinity of New York city; but it is a feature common to the coast south of that point, and also obtains at several places in the interior of New England. A relatively light rainfall during September is characteristic of the State at large; whereas in the Upper Lake region the general autumn maximum occurs during that month. Erie, Pa., shows a November maximum, which feature also prevails in the Ohio Valley.

Over the greater part of the interior of New York the precipitation during the winter is the least of the year. Eastern Long Island, on the contrary, has its annual maximum at that season; while the coast stations generally appear to be about equally subject to continental and maritime influences, showing but slight seasonal variations. This is also true, in even a greater degree, of the region bordering the Lower Lakes, and Rochester may be taken as an example in which an annual fluctuation is almost wholly lacking. Oswego has a principal maximum in June, and a secondary in autumn and early winter; but the latter becomes predominant at Palermo, a few miles to the eastward, and attains a remarkable intensity along the ridge running parallel to the lake in Lewis County.

In the *spring*, a March maximum is very pronounced at the Atlantic coast stations, and is also observable inland in a lesser degree. A diminution again occurs in April, after which the curves of the continental type rise towards their summer maximum, corresponding to the change of prevailing winds from northerly to southerly which occurs in May.

Local Thunderstorms occur almost daily in some portions of the State during the summer months. They form most frequently over the high hills of southern and eastern New York, thence drifting in a general easterly direction, at a rate of about 30 miles per hour, often as far as the coast or over New England. Regions showing a pronounced summer maximum of rainfall, as a rule, owe this feature to frequent thunderstorms.

Figure 20 indicates the regions in which local thunderstorms most frequently originate, and the directions in which they are

most likely to move and spread out. Figure 21 shows the progress of a thunderstorm of a more general character, advancing

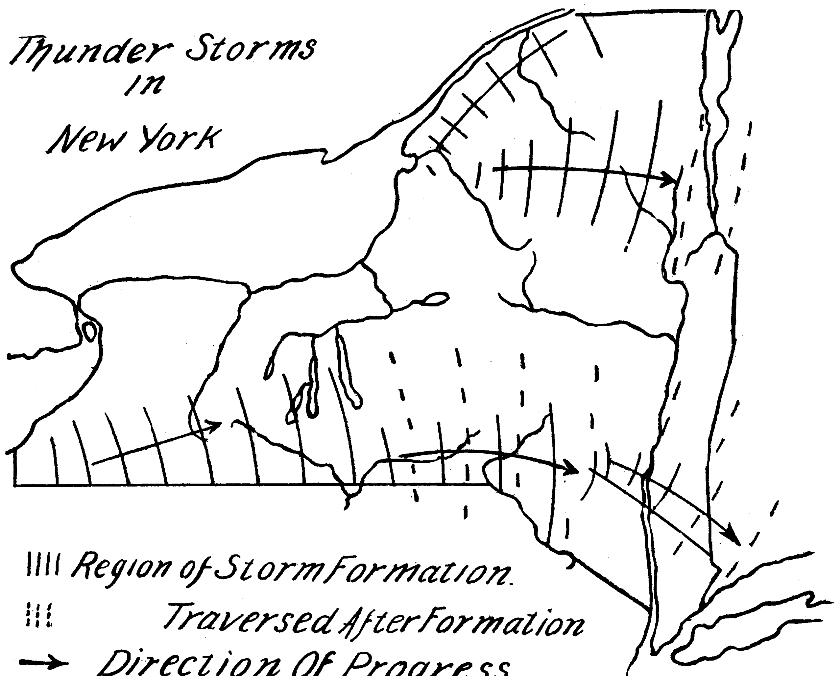


FIG. 20.

in front of a large high-pressure area, and preceding a change of weather.

FREQUENCY OF RAINY DAYS.

The accompanying table shows the average frequency with which a rain or snow fall amounting to one one-hundredth of an inch or more occurs, during each month, at six stations in New York and also at Block Island, R. I., and at Erie, Pa., the former station representing, approximately, eastern Long Island and the latter southwestern New York. The rainy days are here expressed in percentages of the total number of days in each month, following the method of the Signal Service charts, from which the values at all stations excepting Ithaca were derived.

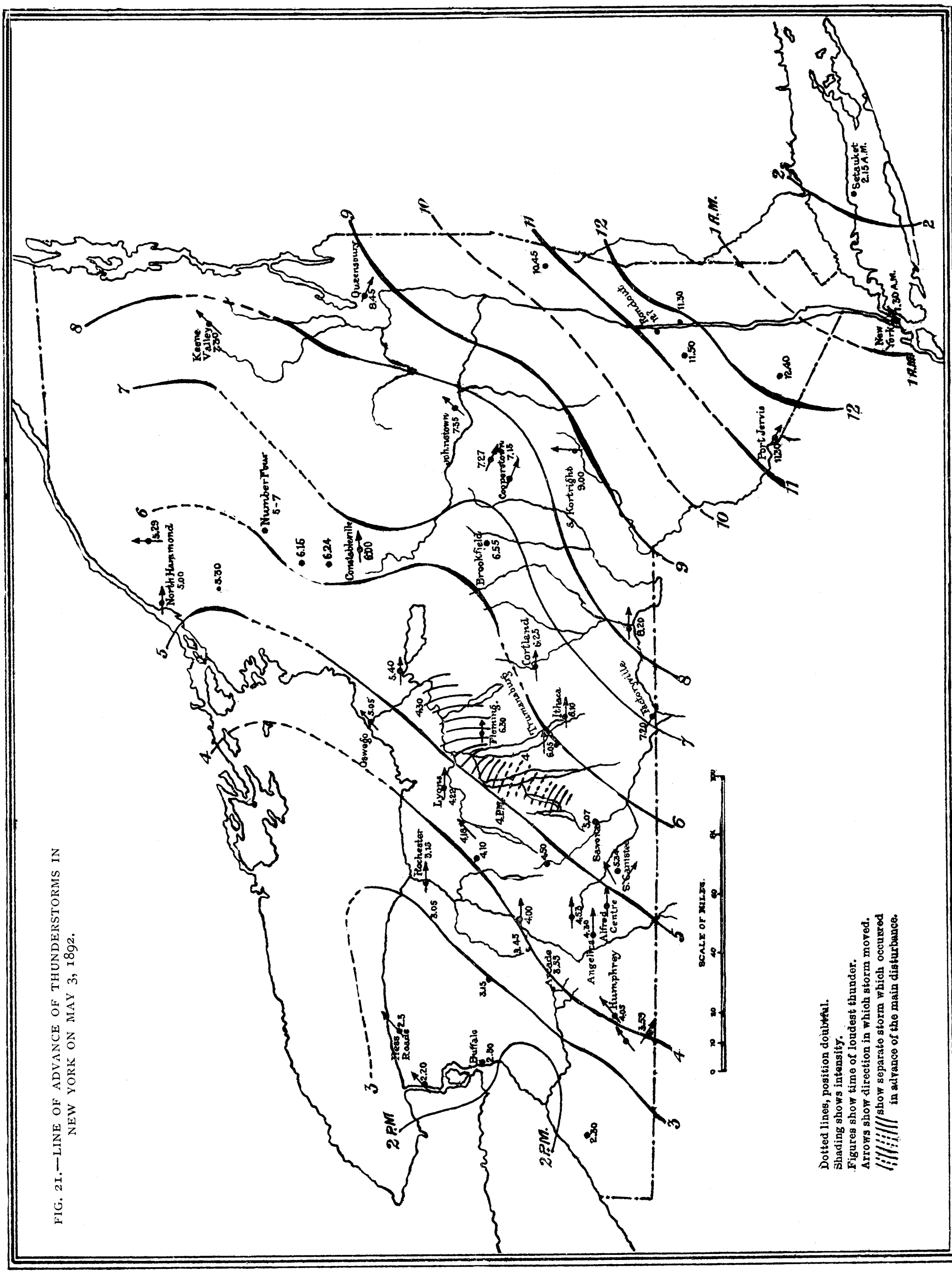


FIG. 21.—LINE OF ADVANCE OF THUNDERSTORMS IN NEW YORK ON MAY 3, 1892.

Dotted lines, position doubtful.
Shading shows intensity.
Figures show time of loudest thunder.
Arrows show direction in which storm moved.
////// show separate storm which occurred in advance of the main disturbance.

PERCENTAGE OF RAINY DAYS.

STATION.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total annual No.
Block Island, R. I	47	44	39	35	38	32	36	29	29	35	39	41	135
New York City	39	39	38	37	34	35	36	32	31	31	34	36	131
Albany	45	43	44	40	40	41	39	31	34	35	43	44	146
Oswego	55	49	40	39	37	36	32	26	35	46	56	55	153
Rochester	65	58	57	42	38	39	37	32	38	47	53	61	171
Buffalo	59	55	55	41	39	39	35	31	38	46	55	59	170
Erie, Pa	65	58	57	44	39	41	33	32	41	51	57	65	178
Ithaca	59	54	46	37	46	40	43	37	37	40	46	50	161

Here it will be seen that the frequency of rain-(or snow-) fall is much more uniform over the State in summer than in winter, when the values are about 25 per cent. larger near the lakes than on the coast.

The probability of rain for all portions of the State may be fairly estimated from the averages at these stations, although some local variation must be expected, especially in summer, when local rains and thunderstorms are found to be quite unequally distributed over the State. It will be observed that precipitation occurs most frequently during the winter months at all stations; but, making allowance for this general tendency, the number of rainy days is found to follow, in a general way, the fluctuations of the rain curves shown in Figs. 17 and 18, which fact may aid in the estimation of rain probability for various special localities.

PERCENTAGE OF CLOUDINESS. (OVERCAST = 100 PER CENT.)

STATION.	COUNTY.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Year.
Block Island, R. I	....	55	48	51	45	51	40	43	44	47	49	51	56	47.5
New York City	New York	57	51	53	52	51	47	48	47	46	47	51	56	50.5
Liberty	Sullivan	62	62	60	57	49	47	44	45	43	52	66	66	54.0
Albany	Albany	60	57	61	58	52	48	48	50	50	58	60	79	56.0
Burlington, Vt.	....	57	58	64	53	56	44	46	40	51	70	61	72	56.0
Hamilton College	Oneida	76	74	65	56	48	43	38	36	39	57	75	79	57.0
Homer	Cortlandt	76	76	68	61	54	60	47	47	50	61	80	79	63.0
Elmira	Chemung	66	62	54	54	47	52	45	45	51	55	66	66	55.0
Geneva	Ontario	71	69	62	58	48	48	42	41	45	58	70	74	57.0
Oswego	Oswego	81	74	69	56	51	49	47	47	52	65	80	86	63.0
Rochester	Monroe	80	70	69	56	50	48	45	44	49	60	77	83	61.0
Buffalo	Erie	77	66	64	56	52	48	48	44	50	60	74	81	62.4
Erie, Pa	....	77	66	64	55	52	48	48	44	50	60	74	81	62.4

For our present purposes, the sources of cloud-formation may be included under two heads: 1st, low pressure, or storm, areas; and 2nd, local sources.

Low barometer areas usually bring with them a heavy cloud-

FIG. 22.—MAP OF THE STATE OF NEW YORK SHOWING THE AVERAGE CLOUDINESS FOR THE YEAR.

layer, many hundred of miles in extent; and since such disturbances pass in the vicinity of New York at intervals of three or four days during the winter, a large percentage of cloudy weather must be expected at that season, especially in northern and western New York, which sections lie nearer to the common track of storm centres than does the coast region. The lesser extent and frequency of low barometer areas during the summer months account in a large measure for the increased sunshine which then obtains.

The Great Lakes are the most important source of the *local* clouds, in winter. The vast quantities of vapor which rise from the lake surfaces are condensed by the prevailing cold northwesterly winds, and drift with them in a broad sheet over the greater part of western and central New York. Southeastern New York owes its clearer atmosphere to the fact that the prevailing winds carry the ocean vapors *away* from, and not toward, the coast.

In summer the prevailing southerly winds carry the lake vapors over Canada rather than New York; and also the high air temperature to a large degree prevents condensation and cloud-formation. Hence, during the warm months, fair weather prevails much more uniformly over the State than in winter.

The distribution of cloudiness over the State, for the year, is shown by the accompanying chart.

RELATIVE HUMIDITY. (PER CENT.)

STATION.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Year.
Block Island, R. I.	76	78	75	76	83	83	82	82	82	79	78	79	79
New York City	74	73	68	65	66	69	71	72	72	70	70	73	70
Oswego	74	74	73	68	67	70	71	71	71	71	71	76	71
Albany	75	74	71	63	62	66	67	68	72	72	74	76	70
Rochester	80	77	76	67	64	67	68	68	70	72	76	80	72
Buffalo	80	78	75	71	68	71	72	71	72	73	76	79	74
Erie, Pa	79	78	76	70	66	70	70	70	72	72	75	79	73

Although the *absolute* amount of moisture in the air is least during the winter, the percentage *relatively* to *saturation* (the relative humidity) is then generally at a maximum. At Block Island, however, the northerly winter winds have traversed a lesser expanse of water surface than the southerly or ocean winds of summer, and this circumstance, with the more moderate degrees of heat and cold to which the island is subject, reverses the rule applying to inland stations, causing the maximum humidity to occur during the summer. This is the case also along the south shore of New England and probably over the greater part of Long Island.

The maximum humidity at the Weather Bureau Stations within the State is found at Buffalo, which is subject to prevailing winds from the Lake. The region of least moisture, on the other hand, appears to be the Champlain Valley, as shown by a two years' record at Plattsburgh. The conditions are here very dissimilar to those of stations at the same latitude in the St. Lawrence Valley, the latter region showing substantially the same humidity which prevails near the Great Lakes.

The limits of this paper have rendered it necessary to consider climate as a fixed and definite entity, whose elements are represented by the averages of long series of observations. As a matter of fact, successive years may differ so widely in many or all of their characteristics as to bear little resemblance to the ideal which our averages represent. For example, the highest mean temperature on the records of New York City for January was 40°, which is the *normal* value for that month at Norfolk, Va.; while the coldest January at New York has the same average as the normal at Portland, Me. (20°). The fluctuations of other elements are quite as marked. Rainfall is especially variable, the annual total at Ithaca in one case, for instance, differing from the normal by 50 per cent.

To determine the extent and law of such fluctuations, an examination has been made of the records, which, in this State, extend back to 1826. As regards temperature, it is found that the coldest months of the year are the most variable, and that the variation may amount to 10° either above or below the normal, giving a range of 20°; but has not, so far, much exceeded that amount. In summer, the range of monthly means does not exceed 12°. We also find that deviations of 2° or 3° on either side of the normal occur about as frequently as a closer agreement with the normal; but beyond that limit warm or cold months are less frequent in proportion to their deviation from the normal. The normal has, then, a meaning and value as being approximately the *most probable value*.

The same rule holds in a measure also for precipitation; but the variations of this element are so wide that the formulation of any law becomes hazardous, and certainly is beyond the scope of this article. The rainfall in a single day may exceed that of an entire season, and, as already stated, the annual totals are subject to variations of over 50 per cent. If, however, we compute the total precipitation of the Januarys (say) of a long series of years at a given station, and then for a second period of like duration, the two will agree quite closely, and the more so as the length of the periods is increased.

The normals (which are simply these totals divided by the number of years of the record) thus serve an important purpose in bringing out the *characteristic* fluctuations of rainfall from month to month, and in different regions.

It is often asked, *Is our climate gradually changing?* To this question no perfectly definite and satisfactory answer can as yet be given; but we may at least assert that the changes, if any exist, are not sufficiently important to be readily discernible in the long records at our disposal. Only the broadest survey of climatological evidence can justify any conclusions in this matter, and for such a survey we must look to the work of Brückner in Germany.* This investigator has made use of all available records of weather, ice-formation and fluctuations of level in rivers and lakes, dates of harvest and other historical material, for the entire northern hemisphere. He concludes that relatively warm and dry periods alternate with cold and wet periods; the same phases recurring at intervals of about 35 years, or more accurately, as follows:

WARM AND DRY.	COLD AND WET.
1791–1805	1806–1820
1821–1833	1836–1850
1851–1870	1871–1885
(1886–1905)	....

The cold years differ from the warm years by about 2°; and the dry years from the wet by about 20 per cent. of the total precipitation. These results have little value, however, excepting in their scientific aspect; for they show wide deviations from the data of a restricted region like our own, and furnish but little basis for local predictions. The progress of deforestation is also often said to be the cause of important changes in climate; but the most careful investigation of the subject has hitherto given only negative results.

* See "Modern Meteorology," by F. Waldo, Scribners.